CLAIMS

WHAT IS CLAIMED IS:

1. An apparatus for screening members of a library comprising:
   a plurality of vessels for receiving library members, each of the vessels having an inlet and an outlet;
   a detector for analyzing vessel effluent; and
   a fluid handling system comprising:
   an entrance control volume in fluid communication with the inlet of each of the vessels;
   an exit control volume in fluid communication with the outlet of each of the vessels; and
   a plurality of flow restrictors providing fluid communication between each of the vessels and one of the entrance control volume and the exit control volume;
   wherein resistance to fluid flow in the fluid handling system is greatest in the flow restrictors and resistance to fluid flow in each of the flow restrictors is approximately the same, so that maintaining a higher pressure in the entrance control volume than in the exit control volume results in fluid flow through the vessels that is apportioned approximately equally between each of the vessels.
2. The apparatus of claim 1, further comprising a pressure regulator in the entrance control volume.
3. The apparatus of claim 2, further comprising a pressure regulator in the exit control volume.
4. The apparatus of claim 1, further comprising a hollow sampling probe selectively positioned in the exit control volume to sample fluid flowing from a single flow restrictor and adapted to transport sample fluid to the detector.
5. The apparatus of claim 4, further comprising a sampling valve and a return line, the sampling valve providing selective fluid communication between the

sampling probe and the return line, and between the sampling probe and the detector;

wherein the return line vents fluid into the exit control volume.

6. The apparatus of claim 1, further comprising:

a plurality of outlet conduits and a selection valve, the outlet conduits providing fluid communication between the outlet of each of the vessels and the selection valve;

a sample bypass and a sampling valve, the sample bypass providing fluid communication between the selection valve and the sampling valve; and

a return line, the return line providing fluid communication between the sampling valve and the exit control volume;

wherein the selection valve is adapted to divert fluid from a selected vessel to the sample bypass while allowing fluid from non-selected vessels to flow to the exit control volume, and the sampling valve is adapted to provide selective fluid communication between the sample bypass and the return line and between the sample bypass and the detector.

7. The apparatus of claim 1, wherein the fluid handling system further comprises a fluid distribution valve having a first valve portion and a second valve portion, and a plurality of exhaust conduits providing fluid communication between the fluid distribution valve and the exit control volume;

wherein the first valve portion provides selective fluid communication between a test fluid source and the flow restrictors and between the test fluid source and the exhaust conduits;

the second valve portion provides selective fluid communication between an inert fluid source and the flow restrictors and between the inert fluid source and the exhaust conduits; and

the resistance to fluid flow in each of the exhaust conduits is approximately the same and is about equal to the resistance to fluid flow in each of the flow restrictors, so that fluid flow is apportioned approximately equally between each of the vessels and exhaust conduits.

8. The apparatus of claim 1, wherein the flow restrictors are one of capillary tubes, micromachined channels, and pin holes.

9. The apparatus of claim 1, further comprising:
flow regulators located along flow paths between the flow restrictors and one of the entrance control volume, the exit control volume and the vessels.

10. The apparatus of claim 9, wherein each of the flow regulators comprise:
a flow sensor in communication with a flow controller;
wherein the flow sensor determines flow rate by detecting a temperature difference between sensor elements located upstream of the flow controller; and
the flow controller adjusts fluid flow rate in response to a signal from the flow sensor by changing fluid temperature in the flow path.

11. The apparatus of claim 1, further comprising a system for regulating temperature of each of the vessels.

12. The apparatus of claim 11, wherein the system for regulating temperature of each of the vessels comprises a heating element and a temperature sensor, the heating element and temperature sensor in thermal contact with the vessels and in communication with a processor;
wherein the processor adjusts the temperature of the vessels in response to a signal from the temperature sensor by changing heat output of the heating element.

13. The apparatus of claim 12, further comprising a plurality of elongated heating elements, wherein all of the elongated heating elements in thermal contact with a particular row of vessels are in approximate axial alignment and are about parallel to the particular row of vessels.

14. The apparatus of claim 1, wherein the detector is one of a gas chromatograph, a mass spectrometer, a visible spectrometer, an ultraviolet spectrometer, and an infrared spectrometer.

15. The apparatus of claim 1 further comprising an assembly for containing the vessels, the assembly comprised of:

a base block having a planar top surface, and a bottom surface, the top surface of the base block having a plurality of wells formed thereon; and

a cover block having a planar bottom surface, the bottom surface of the cover block disposed on the top surface of the base block, and the bottom surface of the cover block having a plurality of depressions formed thereon;

wherein the cover block is removably attached to the base block, and each of the depressions is in substantial alignment with one of the wells, such that the aligned depressions and wells form cavities for containing the vessels.

16. The apparatus of claim 15, wherein the assembly further comprises vessel inlet ports and vessel outlet ports located on the bottom surface of the base cover;

wherein each of the vessel inlet ports provides fluid communication with the inlet of only one of the vessels, and each of the vessel outlet ports provides fluid communication with the outlet of only one of the vessels.

17. An apparatus for screening members of a library comprising:

a plurality of vessels for receiving library members, each of the vessels having an inlet and an outlet;

a detector for analyzing vessel effluent;

a fluid handling system comprising:

an entrance control volume and a plurality of flow restrictors, the flow restrictors providing fluid communication between the entrance control volume and the inlet of each of the vessels;

a plurality of outlet conduits and a selection valve, the outlet conduits providing fluid communication between the outlet of each of the vessels and the selection valve;

a sample bypass and a sampling valve, the sample bypass providing fluid communication between the selection valve and the sampling valve;

a return line and an exit control volume, the return line providing fluid communication between the sampling valve and the exit control

volume, wherein the selection valve is adapted to divert fluid from a selected vessel to the sample bypass while allowing fluid from non-selected vessels to flow to the exit control volume via a common exhaust port, and the sampling valve provides selective fluid communication between the sample bypass and the detector, and between the sample bypass and the exit control volume;

wherein resistance to fluid flow in the fluid handling system is greatest in the flow restrictors and resistance to fluid flow in each of the flow restrictors is approximately the same, so that maintaining a higher pressure in the entrance control volume than in the exit control volume results in fluid flow from the entrance control volume to the exit control volume that is apportioned approximately equally between each of the vessels.

18. The apparatus of claim 17, further comprising a pressure regulator in the entrance control volume.

19. The apparatus of claim 18, further comprising a pressure regulator in the exit control volume.

20. The apparatus of claim 17, wherein the fluid handling system further comprises a fluid distribution valve having a first valve portion and a second valve portion, and a plurality of exhaust conduits providing fluid communication between the fluid distribution valve and the exit control volume;

wherein the first valve portion provides selective fluid communication between a test fluid source and the flow restrictors and between the test fluid source and the exhaust conduits;

the second valve portion provides selective fluid communication between an inert fluid source and the flow restrictors and between the inert fluid source and the exhaust conduits; and

the resistance to fluid flow in each of the exhaust conduits is approximately the same and is about equal to the resistance to fluid flow in each of the

flow restrictors so that fluid flow is apportioned approximately equally between each of the vessels and exhaust conduits.

21. The apparatus of claim 17, further comprising:

a first metering tube and a second metering tube in fluid communication with the sampling valve, the first metering tube and the second metering tube having substantially the same volume, and the sampling valve adapted to switch between a first flow network and a second flow network;

wherein the first flow network provides fluid communication between the sample bypass, the first metering tube and the exit control volume, and between a carrier gas source , the second metering tube, and the detector;

the second flow network provides fluid communication between the sample bypass, the second metering tube and the exit control volume, and between the carrier gas source, the first metering tube and the detector;

so that switching from the first flow network to the second flow network results in transport of sample fluid within the first metering tube to the detector, and switching from the second flow network to the first flow network results in transport of sample fluid within the second metering tube to the detector.

22. The apparatus of claim 21, wherein the overall resistance to fluid flow in each flow path between the vessel outlets and the exit control volume is approximately the same.

23. The apparatus of claim 17, wherein the flow restrictors are one of capillary tubes, micromachined channels, and pin holes.

24. The apparatus of claim 17, further comprising:

flow regulators located along flow paths between the flow restrictors and one of the entrance control volume, the exit control volume and the vessels.

25. The apparatus of claim 24, wherein each of the flow regulators comprise:

a flow sensor in communication with a flow controller;

wherein the flow sensor determines flow rate by detecting a temperature difference between sensor elements located upstream of the flow controller; and

the flow controller adjusts fluid flow rate in response to a signal from the flow sensor by changing fluid temperature in the flow path.

26. The apparatus of claim 17, further comprising a system for regulating temperature of each of the vessels.

27. The apparatus of claim 26, wherein the system for regulating temperature of each of the vessels comprises a heating element and a temperature sensor, the heating element and temperature sensor in thermal contact with the vessels and in communication with a processor;

wherein the processor adjusts the temperature of the vessels in response to a signal from the temperature sensor by changing heat output of the heating element.

28. The apparatus of claim 27, further comprising a plurality of elongated heating elements, wherein all of the elongated heating elements in thermal contact with a particular row of vessels are in approximate axial alignment and are about parallel to the particular row of vessels.

29. The apparatus of claim 17, wherein the detector is one of a gas chromatograph, a mass spectrometer, a visible spectrometer, an ultraviolet spectrometer, and an infrared spectrometer.

30. The apparatus of claim 17 further comprising an assembly for containing the vessels, the assembly comprised of:

a base block having a planar top surface, and a bottom surface, the top surface of the base block having a plurality of wells formed thereon; and

a cover block having a planar bottom surface, the bottom surface of the cover block disposed on the top surface of the base block, and the bottom surface of the cover block having a plurality of depressions formed thereon;

wherein the cover block is removably attached to the base block, and each of the depressions is in substantial alignment with one of the wells, such

that the aligned depressions and wells form cavities for containing the vessels.

31. The apparatus of claim 30, wherein the assembly further comprises vessel inlet ports and vessel outlet ports located on the bottom surface of the base cover; wherein each of the vessel inlet ports provides fluid communication with the inlet of only one of the vessels, and each of the vessel outlet ports provides fluid communication with the outlet of only one of the vessels.

32. A reactor for evaluating catalytic performance of members of a combinatorial library by contacting library members with a reactive fluid, the reactor comprising:

a plurality of vessels for receiving library members, each of the vessels having an inlet and an outlet;

a fluid handling system comprising:

an entrance control volume in fluid communication with the inlet of each of the vessels;

an exit control volume in fluid communication with the outlet of each of the vessels; and

a plurality of flow restrictors providing fluid communication between each of the vessels and one of the entrance control volume and the exit control volume;

wherein resistance to fluid flow in the fluid handling system is greatest in the flow restrictors and resistance to fluid flow in each of the flow restrictors is approximately the same, so that maintaining a higher pressure in the entrance control volume than in the exit control volume results in fluid flow through the vessels that is apportioned approximately equally between each of the vessels.

33. The reactor of claim 32 further comprising a pressure regulator in the entrance control volume.

34. The reactor of claim 33 further comprising a pressure regulator in the exit control volume.

35. The apparatus of claim 32, further comprising a sampling probe selectively positioned in the exit control volume to sample fluid flowing from a single flow restrictor and adapted to transport sample fluid to a detector.

36. The apparatus of claim 35, further comprising a sampling valve and a return line, the sampling valve providing selective fluid communication between the sampling probe and the return line, and between the sampling probe and the detector;

wherein the return line vents fluid into the exit control volume.

37. The apparatus of claim 32, further comprising:

a plurality of outlet conduits and a selection valve, the outlet conduits providing fluid communication between the outlet of each of the vessels and the selection valve;

a sample bypass and a sampling valve, the sample bypass providing fluid communication between the selection valve and the sampling valve; and

a return line, the return line providing fluid communication between the sampling valve and the exit control volume;

wherein the selection valve is adapted to divert fluid from a selected vessel to the sample bypass while allowing fluid from non-selected vessels to flow to the exit control volume, and the sampling valve is adapted to provide selective fluid communication between the sample bypass and the return line and between the sample bypass and a detector.

38. The apparatus of claim 37, further comprising:

a first metering tube and a second metering tube in fluid communication with the sampling valve, the first metering tube and the second metering tube having substantially the same volume, and the sampling valve adapted to switch between a first flow network and a second flow network;

wherein the first flow network provides fluid communication between the sample bypass, the first metering tube and the exit control volume, and

between a carrier gas source , the second metering tube, and the detector;

the second flow network provides fluid communication between the sample bypass, the second metering tube and the exit control volume, and between the carrier gas source, the first metering tube and the detector;

so that switching from the first flow network to the second flow network results in transport of sample fluid within the first metering tube to the detector, and switching from the second flow network to the first flow network results in transport of sample fluid within the second metering tube to the detector.

39. The apparatus of claim 38, wherein the overall resistance to fluid flow in each flow path between the vessel outlets and the exit control volume is approximately the same.

40. The apparatus of claim 32, wherein the fluid handling system further comprises a fluid distribution valve having a first valve portion and a second valve portion, and a plurality of exhaust conduits providing fluid communication between the fluid distribution valve and the exit control volume;

wherein the first valve portion provides selective fluid communication between a reactive fluid source and the flow restrictors and between the reactive fluid source and the exhaust conduits;

the second valve portion provides selective fluid communication between an inert fluid source and the flow restrictors and between the inert fluid source and the exhaust conduits; and

the resistance to fluid flow in each of the exhaust conduits is approximately the same and is about equal to the resistance to fluid flow in each of the flow restrictors, so that fluid flow is apportioned approximately equally between each of the vessels and exhaust conduits.

41. The apparatus of claim 32, wherein the flow restrictors are one of capillary tubes, micromachined channels, and pin holes.

42. The apparatus of claim 32, further comprising:

flow regulators located along flow paths between the flow restrictors and one of the entrance control volume, the exit control volume and the vessels.

43. The apparatus of claim 42, wherein each of the flow regulators comprise:

a flow sensor in communication with a flow controller;

wherein the flow sensor determines flow rate by detecting a temperature difference between sensor elements located upstream of the flow controller; and

the flow controller adjusts fluid flow rate in response to a signal from the flow sensor by changing fluid temperature in the flow path.

44. The apparatus of claim 32, further comprising a system for regulating temperature of each of the vessels.

45. The apparatus of claim 44, wherein the system for regulating temperature of each of the vessels comprises a heating element and a temperature sensor, the heating element and temperature sensor in thermal contact with the vessels and in communication with a processor;

wherein the processor adjusts the temperature of the vessels in response to a signal from the temperature sensor by changing heat output of the heating element.

46. The apparatus of claim 45, further comprising a plurality of elongated heating elements, wherein all of the elongated heating elements in thermal contact with a particular row of vessels are in approximate axial alignment and are about parallel to the particular row of vessels.

47. The apparatus of claim 32 further comprising an assembly for containing the vessels, the assembly comprised of:

a base block having a planar top surface, and a bottom surface, the top surface of the base block having a plurality of wells formed thereon; and

a cover block having a planar bottom surface, the bottom surface of the cover block disposed on the top surface of the base block, and the bottom surface of the cover block having a plurality of depressions formed thereon;

wherein the cover block is removably attached to the base block, and each of the depressions is in substantial alignment with one of the wells, such that the aligned depressions and wells form cavities for containing the vessels.

48. The apparatus of claim 47, wherein the assembly further comprises vessel inlet ports and vessel outlet ports located on the bottom surface of the base cover; wherein each of the vessel inlet ports provides fluid communication with the inlet of only one of the vessels, and each of the vessel outlet ports provides fluid communication with the outlet of only one of the vessels.

49. A method of screening members of a combinatorial library comprising the steps of:

confining a group of library members in a plurality of vessels, each of the confined library members present in about the same amount within each of the vessels;

contacting each of the confined library members with a test fluid by flowing the test fluid through each of the vessels;

detecting changes in the test fluid following contact with each of the confined library members; and

relating changes in the test fluid to a property of each of the library members;

wherein the contacting step is carried out simultaneously for at least two of the confined library members, the detecting step is carried out simultaneously for the at least two of the confined library members, and the amount of test fluid flowing through each of the vessels per unit time is about the same.

50. The method of claim 49, wherein the time from initial contact with the test fluid to detection of changes in the test fluid is approximately the same for each of the confined library members.

51. The method of claim 49, wherein changes in the composition of the test fluid are measured in the detecting step.

52. The method of claim 51, wherein changes in the composition of the test fluid are measured by one of gas chromatography, mass spectrometry, visible spectrometry, ultraviolet spectrometry, and infrared spectrometry.

53. The method of claim 49, wherein the test fluid can undergo chemical reaction in the contacting step.

54. The method of claim 53, wherein the property of each of the library members is catalysis of the chemical reaction.

55. The method of claim 54, wherein changes in the composition of the test fluid are measured in the detecting step.

56. The method of claim 55, wherein the total time to screen at least six library members is less than about six minutes.

57. The method of claim 55, wherein the total time to screen at least six library members is less than about three minutes.

58. The method of claim 55, wherein the total time to screen at least 48 library members is less than about 48 minutes.

59. The method of claim 55, wherein the total time to screen at least 48 library members is less than about 24 minutes.

60. The method of claim 49, wherein the confined library members are exposed to one of a uniform temperature, and a linear temperature gradient.

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